Cavity String Assembly Mechanical Steps at DESY (updated)

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Cavity#1 to Gate Valve Connection:

Parts:

- One gate valve cleaned at DESY Vacuum department.
- Cavity #1 with a blank off flange on the long end beam pipe side and a blank-off flange / right angle valve on the short end beam pipe side.

Hardware:

- 316LN M8 35 mm long studs with Allan head and M8 silicon bronze nuts. M8 SS bolts for Conflat flanges. Aluminum diamond seal, Copper Conflat seal.

Nomenclature:

Particle Free Flange Assembly: PFFA (N/A for the Bellows Assembly)

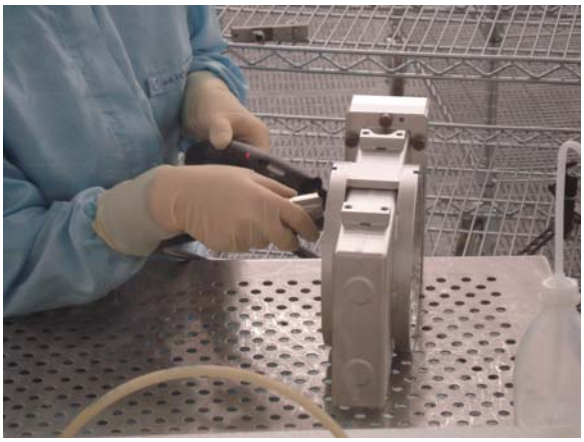
1. Remove blank off flange by removing 4 studs and silicon bronze nuts. Remove the studs from the through holes. Blow ionized nitrogen to the through holes. Ensure the particle count is less than 10.
2. Slowly install 4 new clean studs to the cleaned through holes (Slowly finger tighten with two silicon bronze nuts on each end of the studs).
3. Unscrew the remaining studs/nuts and remove them from the through holes.
4. Clean the through holes by blowing ionized nitrogen through the holes until the particle count is less than 10.
5. Remove the 4 finger tight screws and move the loose blank flange downwards and away holding it with your hand from the bottom edge.

Cavity long end beam pipe side:
Cavity end without the right angle valve where end tuner is installed.

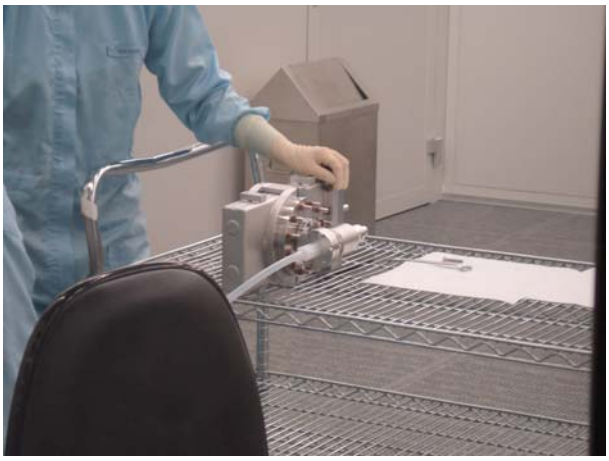
Cavity short end beam pipe side:
Cavity end where the right angle valve is attached.

Assembly steps:

1. Clean the gate valve by blowing ionized nitrogen in all the blind holes; this is performed on a work bench.
2. Open the gate valve half way while blowing ionized nitrogen. Then open valve completely and finish blowing clean. Leave the gate valve open after it is cleaned.

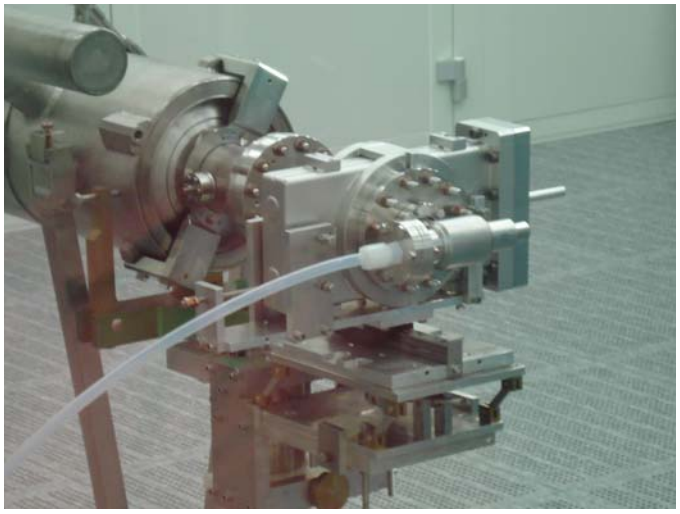


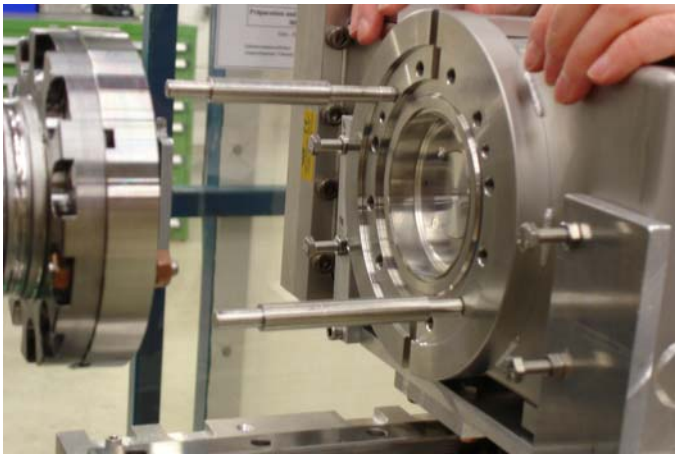
3. Blow all associated hardware clean (nuts, studs, washers, diamond seals, conflat seals).
4. Install a cleaned blank off flange with a cleaned diamond seal onto the gate valve flange facing Cavity #1. This is performed on a work bench. Use only 4 studs and finger tighten the studs.
5. Assemble a cleaned right angle valve with a Conflat flange onto a blank off flange on the work bench.
6. Assemble (the above step 5) right angle valve / blank off assembly onto the gate valve flange while the gate valve is laying flat on the workbench (this is the non-cavity side of the gate valve).
7. Attach a Conflat Flange/Teflon Purge Connector combo to the right angle valve of the gate valve using proper PFFA.

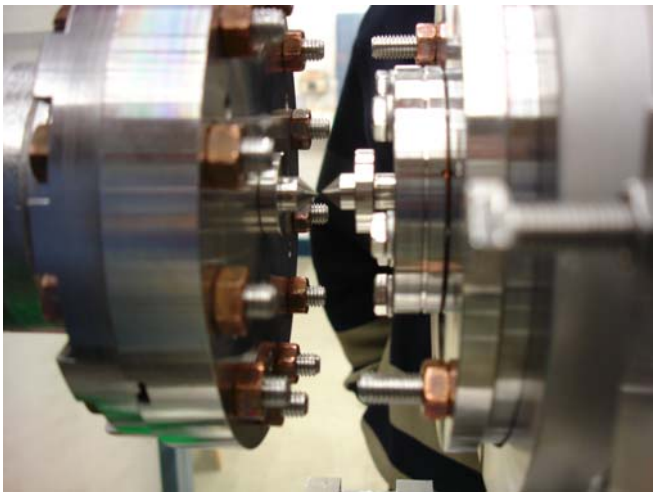


8. Install the blanked-off gate valve onto its fixture and secure the fixture to the table this is attached to the cavity support leg.
9. Turn on Argon flow through a Teflon flexible purge line set to 50 mbar set point.
10. Check hose flow for particulate with particle counter calibrated for Argon. Insure of low count before moving on.
11. Hook up a Conflat flange Vacuum/Purge line (bellow hose) using proper PFFA to the right angle valve on the short end beam pipe of the cavity #1.

12. Pump down the line and leak check the Conflat flange.
13. Ensure there is equal or better vacuum in the line than the Cavity #1.
14. Open the right angle valve of the Cavity #1 very slowly.
15. Leak check all the flanges of the Cavity #1.
16. If leak check is good, valve off from leak detector.
17. Backfill flowing argon at a rate of 1 liter per minute to vent the cavity to 50 mbar.
18. Remove 2 studs from the long end side of cavity #1 blank off at the 10 and 4 o'clock positions.
19. Ensure the rotational alignment of the gate valve flange to the cavity blank off with alignment rods. There are only 4 studs finger tight installed on the blank off flange of the gate valve at this time.
20. Ensure the X-Y axis axial and vertical alignment (parallelism) of the gate valve blank off flange to the cavity blank off flange with the alignment tooling fixtures.







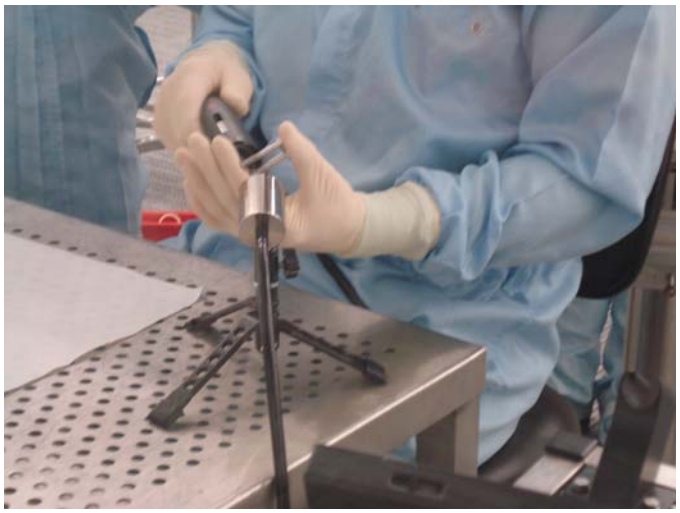
21. Remove cavity studs at 2 and 8 o'clock and repeat steps 18 and 19.
22. Once the rotational and X-Y axis alignment of the gate valve is ensured by performing adjustments on the table and the fixture that holds the gate valve, make sure that the adjustment knobs and set screws are not touched afterwards.
23. Blow ionized nitrogen to the through holes of the cavity blank off (long end beam pipe side). Ensure the particle count is less than 10.
24. Slowly screw 4 new clean studs into the cleaned through holes on the cavity (slowly finger tighten with two silicon bronze nuts on each end of the studs)
25. Unscrew the remaining 8 studs/nuts and remove them from the through holes.
26. Clean the holes by blowing ionized nitrogen through the holes and ensure the particle count is less than 10.
27. Blow ionized nitrogen to the critical envelop (around the flanges to make ensure that the particle count is less than 10)
28. Change gloves
29. Remove the 4 finger tight screws while pressing the flange towards the gate valve and move the loose blank flange away and downwards holding it with your hand from the bottom edge. Ensure that the aluminum gasket does not fall during removal of the flange. Argon purge will automatically start once the pressure inside the gate valve drops below 50 mbar.

30. Install a cleaned diamond shape aluminum seal on the gate valve flange. (Ensure seal has been visually inspected and cleaned). Squeeze the seal slightly to form an ellipse and install the seal on the gate valve flange.
31. Remove the 4 finger tight studs pressing the flange towards the cavity #1 and move the loose blank off flange downwards and away holding it with your hand from the bottom edge. Ensure that the aluminum gasket does not fall during removal of the flange. Argon purge will automatically start once the pressure inside the cavity #1 drops below 50 mbar.
32. While the cavity long end beam pipe and gate valve flange are open and argon is flowing from both sides, slowly slide the aligned gate valve towards the cavity on the assembly table linear guide.
33. Ensuring the alignment (rotational/axial/vertical) setting is right, push the gate valve towards the cavity flange and apply pressure from the gate valve's purge side to ensure slight compression of the gasket. The pressure needs to be applied to the gate valve on the beam axis standing away from the gate valve.
34. Install 4 clean M8 Allan head studs through the cavity flange holes into the blind holes on the gate valve and gently tighten clean silicon bronze nuts with a wrench. Once the gasket is under compression, install the remainder of the M8 Allan head studs w/nuts.
35. After the gate valve is installed, before removing the fixture and the table that hold the valve, install the fixture to support gate valve from the 2 phase helium supply for the remainder of the assembly work.

36. Close the right angle valve on the gate valve.
37. Close the right angle valve on the Cavity #1 short end beam pipe.
38. Pump down the vacuum manifold line.
39. Leak check the flex hose to 90 degree valve joint.(if joint is OK, continue)
40. Open the right angle valve on the Cavity #1 slowly and pull vacuum on the cavity.
41. Conduct a rough leak check.
42. Leave the cavity under vacuum pumping overnight and conduct a leak in the morning.
43. After the leak check, close the right angle valve of the cavity and leave the cavity under vacuum.
44. Now Cavity #1 and gate valve are assembled and the assembly is sealed off under vacuum.

Notes:

- DESY does not use a torque wrench in the clean room except for the right angle valves.
- When the flanges to the cavity are open, DESY personnel always work from the bottom of the cavity to move the blank off flanges down and away from the cavities.
- When the alignment settings are done, particulates are created. These particulates need to be blown away with ionized nitrogen before the blank off flanges can be opened.
- All the hardware and parts are cleaned in ultrasonic cleaners and/or wiped with lint free cloth and blown with ionized nitrogen to ensure less than 10 particle count before they are installed on the cavity string.

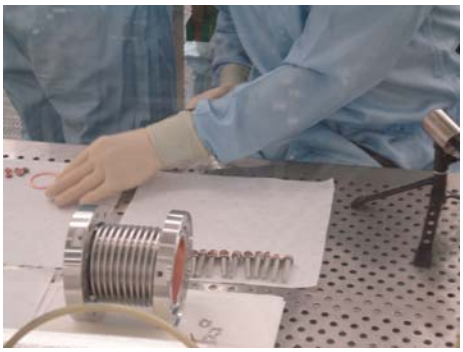


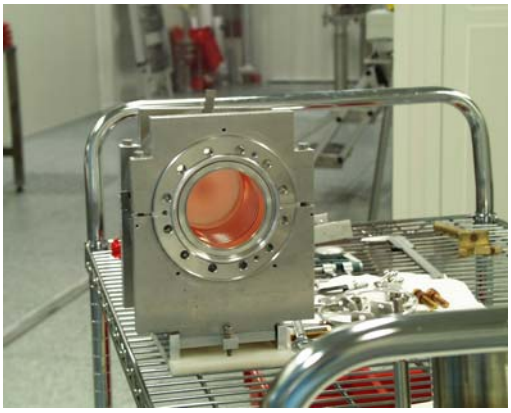
- Technicians do not lean over the joint while working; they try to distance themselves from the joint as much as possible to minimize contamination possibilities.

Cavity#2 to Bellow Assembly Connection:

Parts:

- One bellows, a blank off plate, bellows holder fixture, bellows alignment fixture





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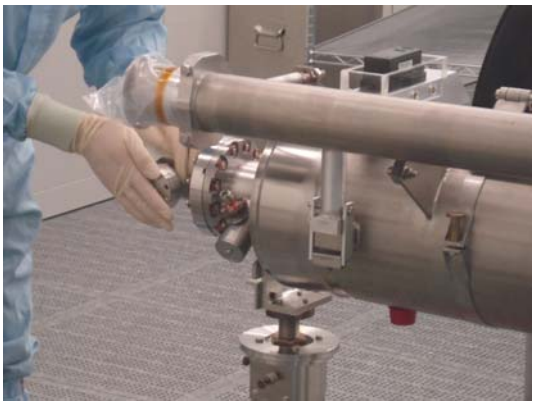
- Cavity #2 with a blank off flange on the long end beam pipe side and a blank off flange / right angle valve on the short end beam pipe side.

Hardware:

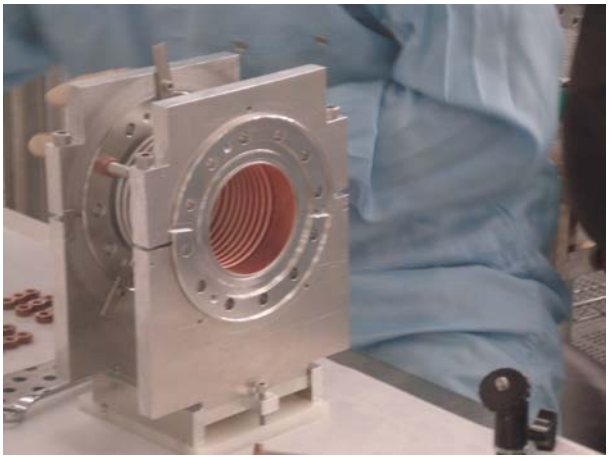
- 316LN M8 50 mm long studs and M8 silicon bronze nuts

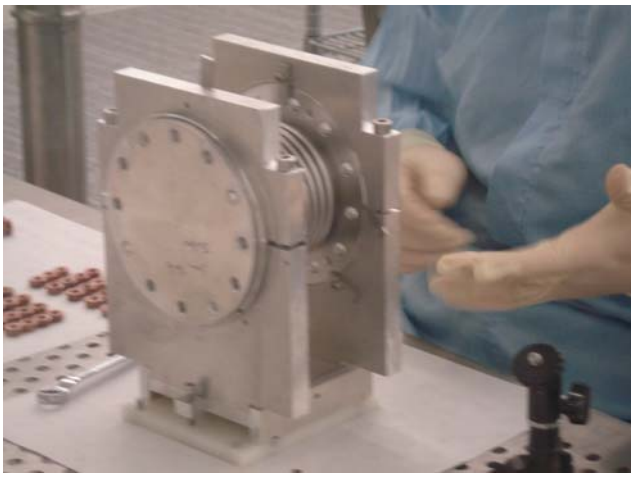
Assembly Steps:

1. Blow clean the assembly hardware (nuts, bolts, conflat seals, etc) for the assembly and purging of cavity # 2.
2. Assemble a Conflat flange Vacuum/Purge line (bellows hose) to the right angle valve on the short end beam pipe side of the cavity#2 using proper PFFA. Make sure the right angle valve is closed.

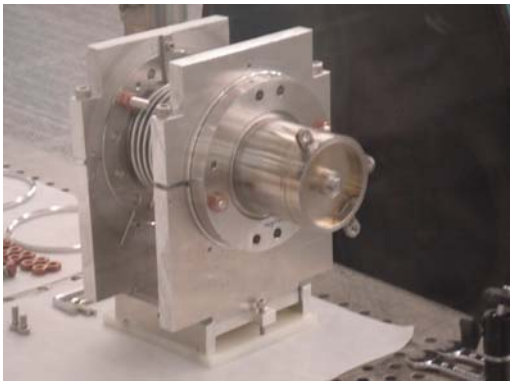


3. Pump the line and leak check the Conflat flange.
4. Pump manifold line to a vacuum better than cavity#2.
5. Open the right angle valve very slowly (ensure the line has an equal or better vacuum than the cavity#2).
6. Leak check all the flanges of the Cavity #2.
7. If leak check is good valve off from leak detector.
8. Backfill cavity#2 with argon to 50mbar. (25 minutes approx. 1 liter per minute flow rate ensured by a micrometer needle purge valve)
9. Blow ionized nitrogen on the bellows alignment fixture, bellows holder fixture and blank off flange.
10. Assemble a blank off plate to the rotatable flange side of the bellow with two studs. (No seal). Ensure proper clocking alignment of the rotatable flange and the non-rotatable flange before tightening these 2 studs. This is done by aligning the flats on both flanges in the same plane.
11. Install the bellows on the bellows clamping fixture



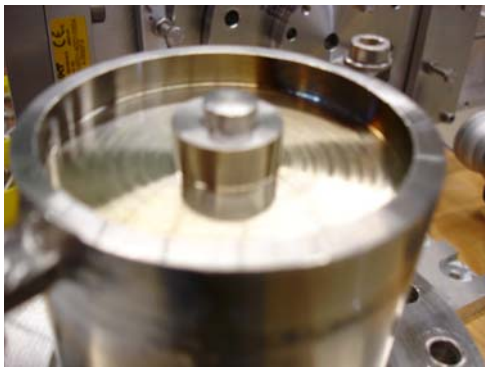


12. Install the axial and vertical (X-Y) [parallelism] alignment fixture on the bellows on the non-rotatable (NR) flange side with 2 studs.



13. Install the bellows assembly with its clamping fixture on the assembly table between Cavity #2 and Cavity #1.

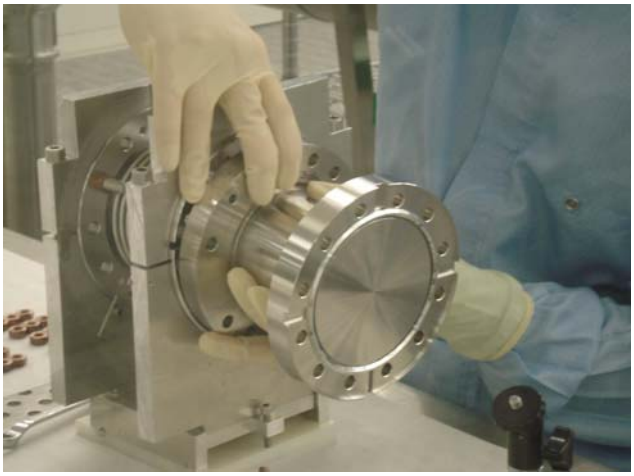
14. Slide the bellows assembly with the alignment fixture to the cavity blank off flange. Ensure rotational and X-Y alignment of the bellows assembly to the cavity #2 blank off flange with proper adjustment of the assembly table and the bellows clamping fixture adjustment screws. Bolt the alignment fixture to the cavity blank off flange with 2 screws. These 2 screws assure the right clocking position of the rotatable and non rotatable flanges of the bellows assembly. The X-Y alignment of the bellows is done by a cylindrical nipple between the bellow alignment piece and cavity blank off flange.



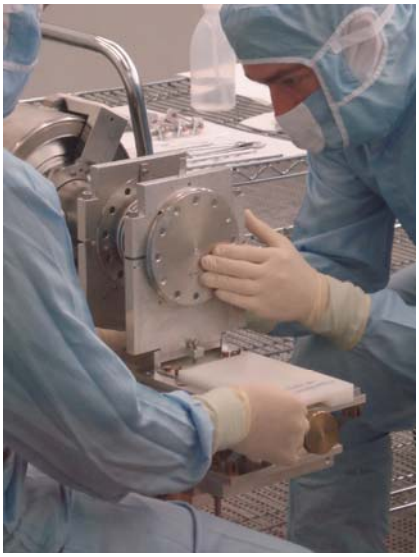
15. Once the alignment settings are performed, remove the bellow assembly with alignment fixture from the post tooling to a work bench.
16. Remove the cavity #2 blank off flange (long end beam pipe side) by removing 4 studs and silicon bronze nuts. Remove the studs from the through hole. Blow ionized nitrogen to the through holes (approx 5 min.) Ensure the particle count is less than 10.

17. Install 4 new clean studs through the cleaned cavity holes (Finger tighten/ snug fit with two clean silicon bronze nuts on each end of the studs.

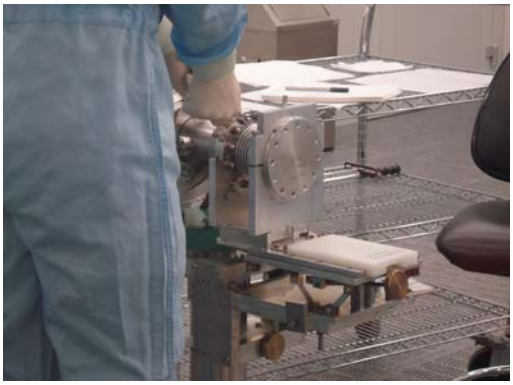
18. Unscrew the remaining studs/nuts and remove them from the through holes.
19. Clean the holes by blowing ionized nitrogen and ensure particle count is less than 10.
20. At this stage, there are 4 finger tight studs on the blank off flange of the Cavity #2 long end beam pipe side. The argon purge may be on and off during this time to ensure 50 mbar positive pressure inside Cavity #2.
21. Put the bellows clamping fixture with the bellow assembly back on the post assembly table.
22. Slide the alignment fixture to the cavity blank off flange and screw the alignment fixture to the blank off flange.
23. Change gloves
24. Remove the 4 finger tight studs and remove the loose blank flange from the cavity #2 (long end beam pipe side) by holding the flange with bellows assembly alignment fixture and bellows clamping fixture. Ensure that the aluminum gasket does not fall during removal of the flange. Argon purge will automatically start once the pressure inside the cavity drops below 50 mbar.
25. Now cavity # 2 is open with argon flow.
26. Move the bellows assembly with its clamping fixture back to the work bench.
27. Disassemble the alignment fixture and blank off flange from the NR flange end of the bellows assembly.



28. Blow ionized nitrogen to the holes and clean the inside of the bellows assembly on the work bench.
29. Install the bellows assembly back on the table without disturbing the already adjusted alignment settings.
30. Put a diamond seal on the open NR flange of the bellows assembly.(Ensure seal has been visually inspected and cleaned)
31. Slide the bellows assembly on the table towards the cavity slowly.



32. Apply hand pressure on the bellows to make sure that the diamond seal is under slight compression before installing clean studs and clean nuts.
33. Torque the studs and the nuts to 30 Newton-meter. DESY personnel do not use a torque wrench in the clean room area.



34. The argon will continue to flow at this stage even though the NR flange of the bellows is assembled on Cavity #2 because rotatable flange of the bellows is only blanked off with a plate with 2 studs and without any diamond seal.

Cavity#1 to Bellow Assembly & Cavity#2 Connection:

Parts:

- Cavity #2 with connected bellow assembly on the long end beam pipe side and a blank off flange / right angle valve on the short end beam pipe side.
- Cavity #1 with connected gate valve on the long end beam pipe side and a blank off flange / right angle valve on the short end beam pipe side.

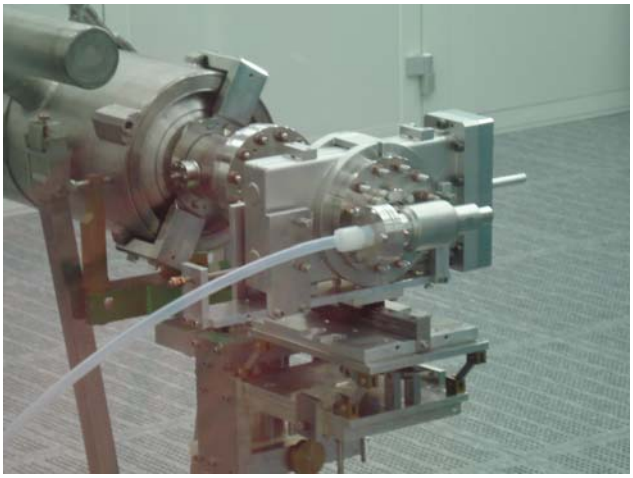
Hardware:

- 316 LN M8 50 mm long studs, M8 silicone bronze nuts

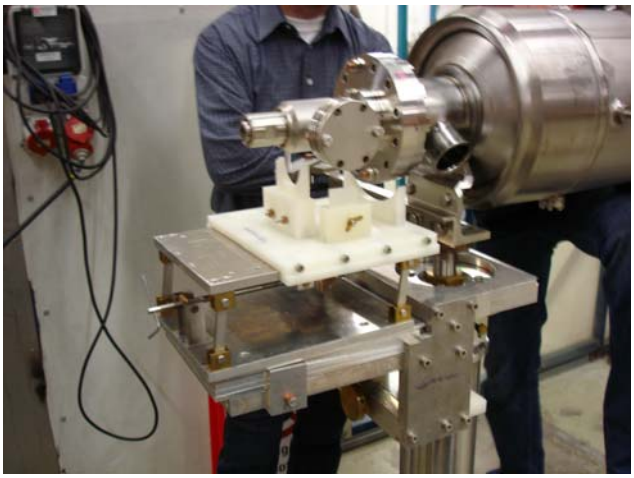
Assembly Steps:

1- Ensure that the right angle valve on the short end beam pipe side of Cavity #1 is closed.

2- Open the right angle valve installed on the gate valve attached to Cavity #1 and start flowing argon to the Cavity #1 (1 liter per minute flow rate).

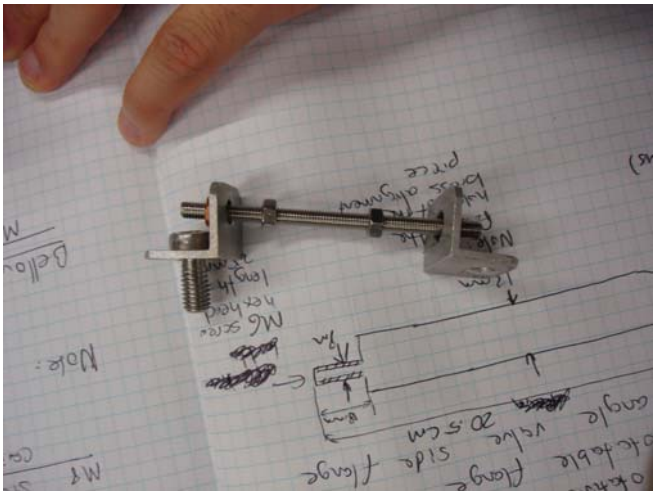


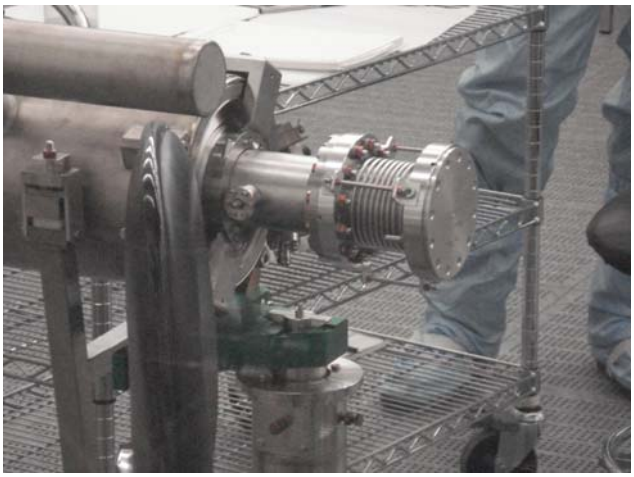
3- Assemble the nylon support fixture under the right angle valve and the blank off flange on the short end beam pipe side of the Cavity #1.



4- Disassemble the bellows clamping fixture from the bellows. (upper side only)

5- Assemble 2 bellows adjusters (stiffeners) between the bellows assembly rotatable and non-rotatable flanges.
6- Remove the bellows clamping tooling by backing off the table adjusting screw and loosening the bolts on the cavity leg stand to rotate the tooling 90 degree.
7- Then remove the lower part of the bellows clamping fixture and assemble a third bellows adjuster at the 6 o'clock position of the bellows.

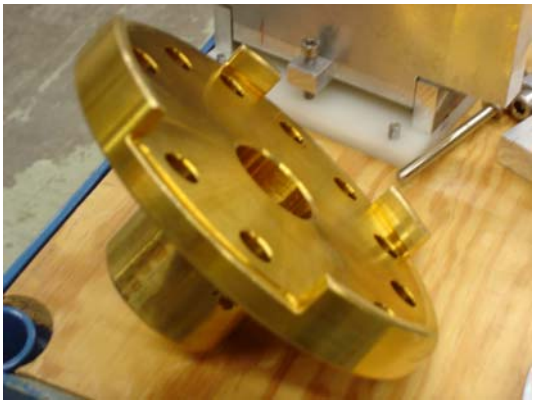




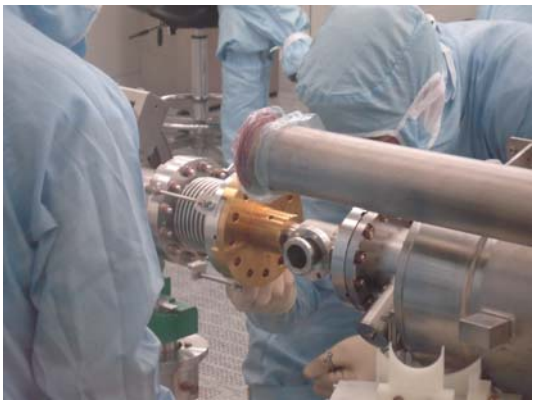
8- Remove 4 studs from the Cavity #1 short end beam pipe side blank-off flange.
9- Install 2 rotational alignment rods between the rotatable bellows flange and Cavity#1 short end beam pipe flange.

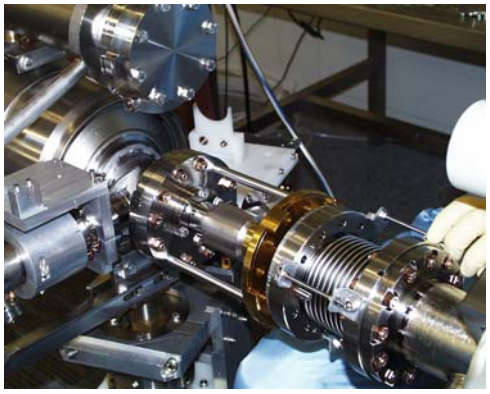
10- Ensure rotational alignment of the bellow assembly to the cavity short end beam pipe blank-off flange by adjusting the bellow stiffeners or by rotating the Rotatable flange to the acceptable clock position if needed.

11- Install the brass X-Y alignment (parallelism) fixture to the end of the right angle valve on the short end beam pipe end of the cavity #1.

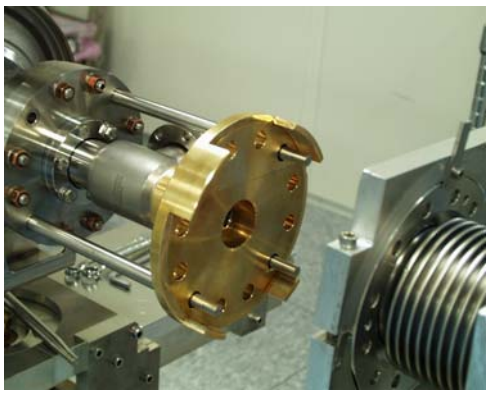


12- Adjust the parallelism of the bellows assembly to the brass fixture by using the bellows adjusters (threaded studs and nuts).

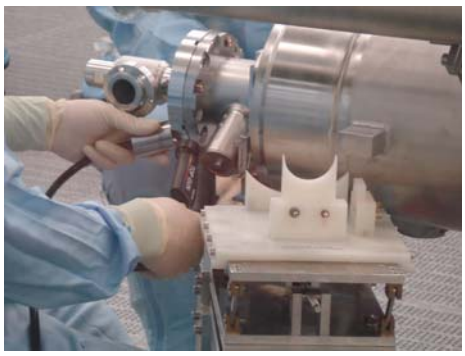




13- Once all the X-Y alignment settings are achieved double check the rotational alignment setting with alignment rods one more time.



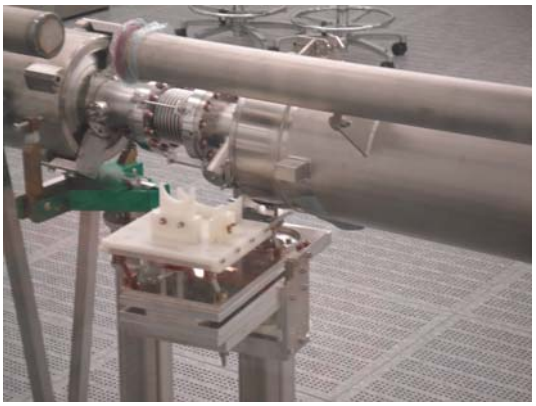
14- Remove the alignment fixtures from the cavity#1 short end beam pipe flange.
15- Disassemble all but 4 studs from the blank off flange and the right angle valve which are attached to cavity #1(right angle valve should currently be closed). Follow the 4 studs removal, blowing ionized nitrogen, 4 new clean studs installation (finger tight) and then removal of the remaining studs and cleaning (blowing nitrogen) for particulate reduction. (PFFA).



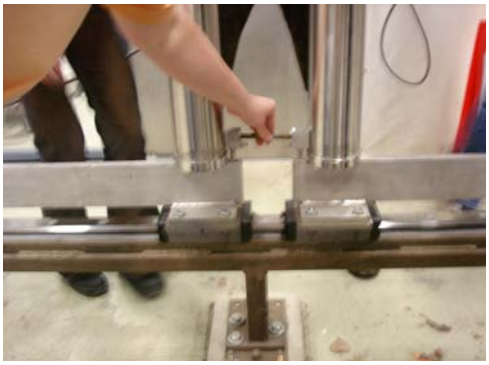
16- At this stage, there are 4 finger tight studs on the blank off flange/right angle valve assembly of the Cavity #1.

17- Make sure the nylon support fixture height is properly adjusted to support the right angle valve and blank off assembly when the 4 finger tight studs are removed.

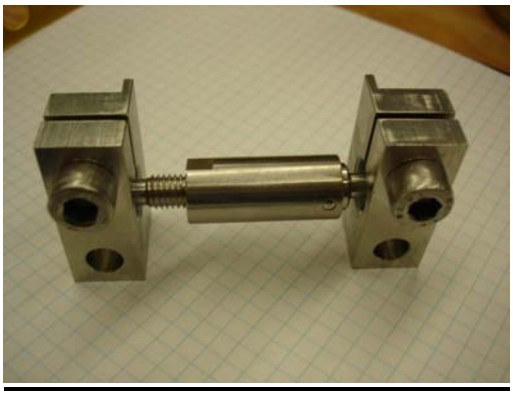
18- Change gloves
19- Remove the 4 finger tight studs and move the loose blank off flange and the right angle valve out of the way by backing off the table height adjusting screw and rotating the assembly support table 90 degrees away from the cavity beam axis. Ensure that the aluminum gasket does not fall during removal of the flange. Argon purge will automatically start once the pressure inside the cavity #1 drops below 50 mbar.
20- Take the right angle valve / blank off assembly off the table and move it to the workbench.
21- Disassemble the blank off plate from the rotatable flange side of the bellows assembly. This plate is attached with only 2 studs to the bellows. It is not leak tight. Cavity #2 is under argon purge flow from the short end beam pipe side right angle valve at this stage.
22- Move the cavity#1 and #2 about 18 in. away from each other before starting to open the bellows connection. This will reduce the chance of cross contamination considering the short end beam pipe on cavity#1 is open.
23- Install a gasket onto the rotatable bellows flange. (Ensure a visual inspection and cleaning has been performed on the diamond seal).
24- Slide the cavity #2 w/bellows assembly and cavity#1 w/gate valve assembly together slowly.
25- Apply some pressure to ensure contact so that the gasket is under slight compression before installing the studs and nuts. Install maximum 4 studs and nuts to have continuous compression on the gasket
26- Install remaining studs and nuts and apply 30 Newton-meter torque to the studs and nuts.

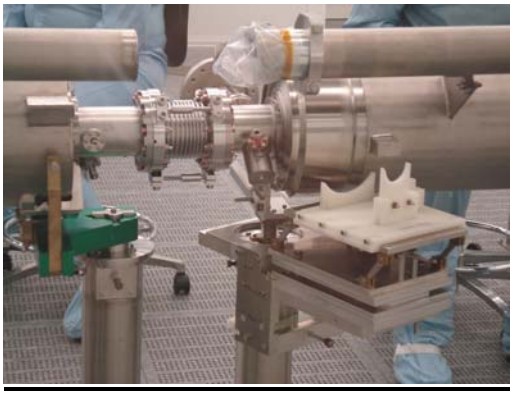


27- The argon purge from both sides of Cavity #1 and Cavity #2 will stop once the interconnect with bellows is tightened.
28- Close the right angle on Cavity #2 and disassemble the bellows hose from Cavity #2. This bellows hose needs to be attached to Cavity #3 with Hall 3 clean room infrastructure.
29- Once the cavity#1 and cavity#2 are interconnected, install the link fixture between the base of cavity #1 post and the base of cavity #2 post.



30- Replace the temporary bellow stiffeners with permanent stiffeners.



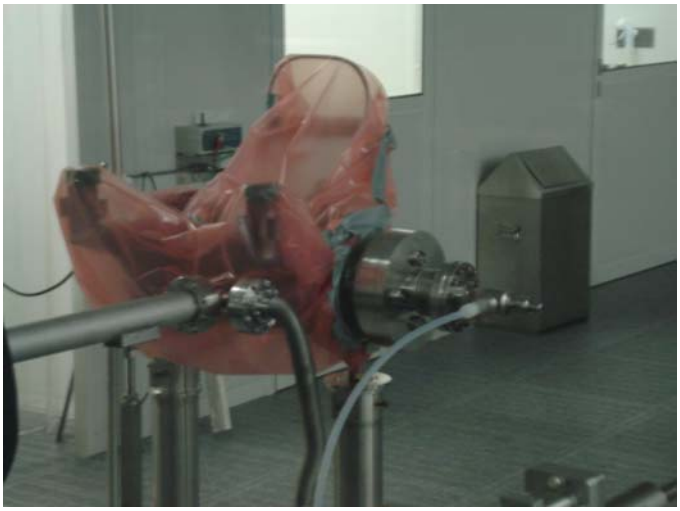


Repeat the same procedure / steps above to interconnect all 8 cavities with bellows.

BPM / Quadrupole to Gate Valve Assembly

Parts:

- One gate valve cleaned at DESY vacuum department
- One Quadrupole (bagged for clean room)
- One BPM (not sealed, end flanges open)



Hardware:

316LN M8 Studs (Allan head), Silicon Copper nuts, Helico-flex Seal (Old Design, changed to diamond seal for X-FEL)

Assembly Steps:

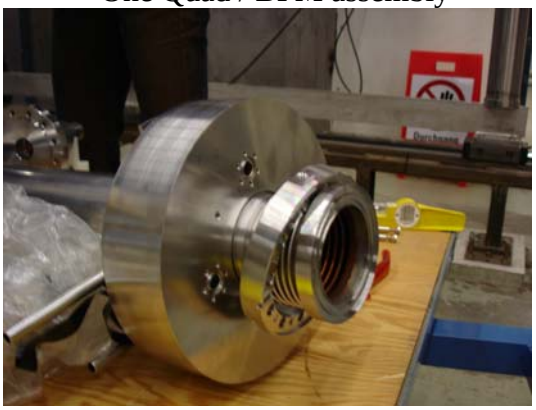
1. Insert BPM into the Quadrupole.
2. Have an ionized nitrogen flow overnight through the BPM tube.
3. Assemble a blank off flange with a right angle valve (Conflat connection) on the work bench.
4. Assemble the blank off flange / right angle valve combo on the rotatable flange end of the BPM
5. Make sure to use bellows stiffners for the BPM bellows to support the blank off flange / right angle valve combo.
6. Attach a Conflat / Teflon valve Argon purge flexible line to the right angle valve and start Argon Flow. The Argon flow speed is such that when the argon leaves the BPM open end, it does not create turbulent air around the flange opening.
7. Attach the necessary split clamping tooling on the other end of the BPM
8. Blow ionized nitrogen in the blind holes of the gate valve on the work bench.
9. Open the gate valve half way while blowing ionized nitrogen. Then open valve completely and finish blowing clean. Leave the gate valve open after it is cleaned.
10. Install a blank off flange and a right angle to the BPM gate valve on the work bench.
11. Install the assembly table to the stand leg
12. Install the gate valve to the assembly fixture and do the necessary alignments
13. Use Helico-flex gasket with light Apiezon putty coating and make the gate valve and BPM end flange connection.

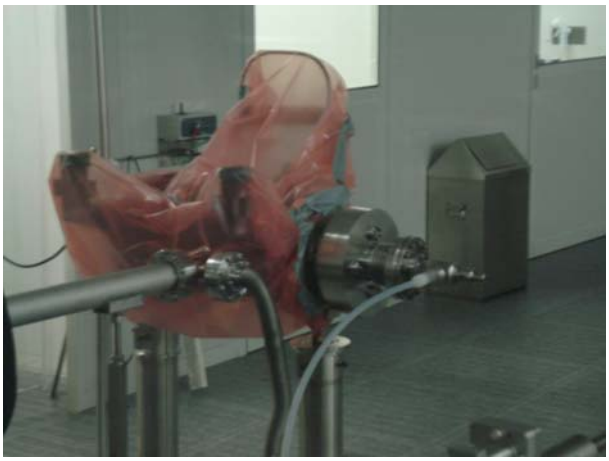
14. Hook up the bellow hose to the right angle valve of the gate valve assembled to the BPM using PFFA. (Conflat connection)
15. Close the right angle valve on the gate valve.
16. Pump down the vacuum manifold line and leak check the Conflat connection on the right angle valve.
17. Close the right angle valve of the bellows side of the BPM.
18. Open the right angle valve of the gate valve slowly
19. Pump down the BPM assembly and do a rough leak check
20. Pump the BPM assembly overnight and conduct a leak check in the morning.
21. Leave the Quad / BPM assembly under vacuum

Quad / BPM to Cavity #8 Connection:

Parts:

- One Quad / BPM assembly





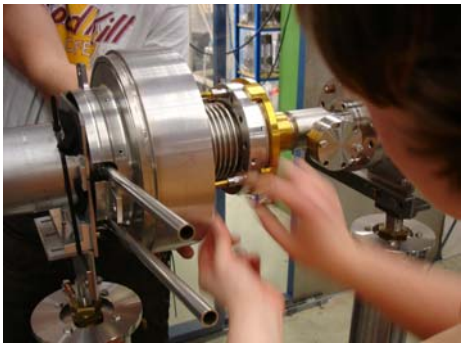
- Cavity#8 with bellow and connected to Cavity#7 on the long end beam pipe side and a blank-off flange / right angle valve on the short end beam pipe side.

Hardware:

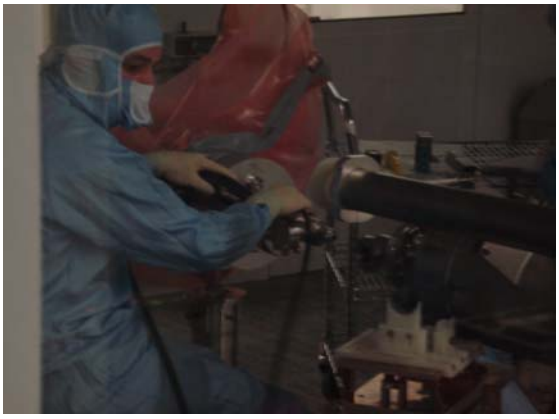
- 316LN M8 50 mm long studs and M8 silicon bronze nuts

Assembly Steps:

1. Assemble the bellows hose the right angle valve on the gate valve of the BPM
2. Pump down and conduct a leak check on the Conflat flange.
3. Open the right angle valve and leak check the BPM tube
4. Purge the BPM tube with Argon set to 50 mbar.
5. Bellow adjusters (seen below) to the end of the BPM assembly are already installed to keep the bellows straight when the blank off flange and right angle valve combo was installed during gate valve to BPM installation.



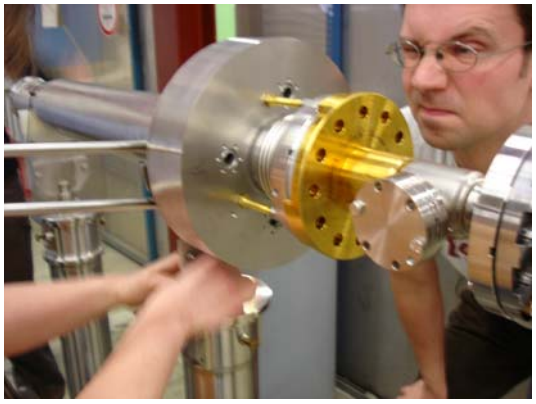
6. Remove the blank off flange / gate valve combo from the BPM bellows side using PFFA.

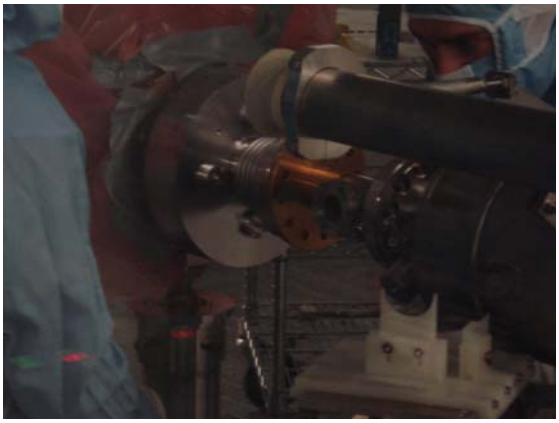


7. Install a plate without any gasket seal with 2 studs to the BPM bellows rotatable flange.

8. Remove 2 studs from the blank off flange of the cavity #8 at the short end beam pipe side flange.
9. Install rotational alignment rods between the BPM bellows and cavity #8 blank-off flange of the short end beam pipe side. The rods are bolted to the cavity #8 short end beam pipe side flange.

10. Install brass X-Y axis alignment (parallelism) tool to the right angle valve at the short end beam pipe side of the Cavity #8 and adjust bellows adjusters for parallelism.

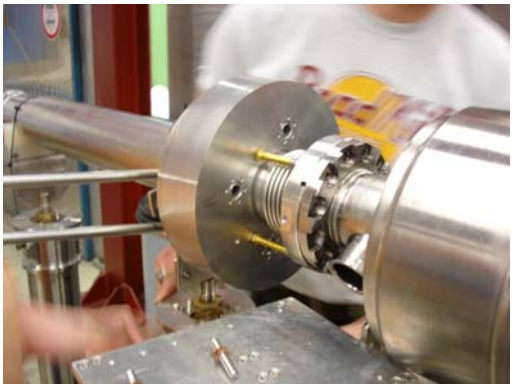




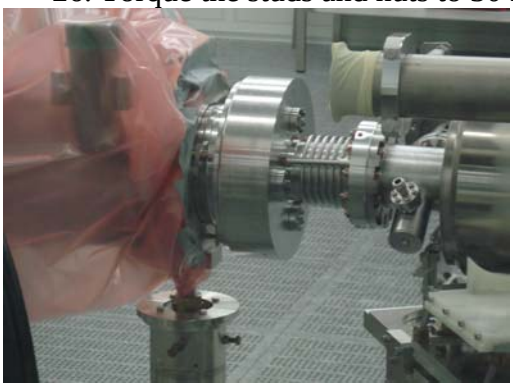
11. Assemble the nylon support fixture under the right angle valve and the blank off flange on the short end beam pipe side of the Cavity #8.

12. Ensure the rotational alignment and X-Y axis alignment setting are correct.
13. Prepare for the removal of the BPM bellows blank off flange by removing 4 studs and silicon bronze nuts. Remove the studs from the through hole. Blow ionized nitrogen to the through holes. Ensure the particle count is less than 10.
14. Install 4 new clean studs to the cleaned through holes (Finger tighten with two cleaned silicon bronze nuts on each end of the studs)
15. Unscrew the remaining studs/nuts and remove them from the through holes.
16. Clean the holes by blowing ionized nitrogen to ensure particle counts less than 10
17. Prepare for the removal of the blank off flange of cavity #8 short end beam pipe side by removing 4 studs and silicon bronze nuts. Remove the studs from the through hole. Blow the through holes with ionized nitrogen to ensure the particle count is less than 10.
18. Install 4 clean studs to the cleaned through holes (Finger tighten with two cleaned silicon bronze nuts on each end of the studs)
19. Unscrew the remaining studs/nuts and remove them from the through holes
20. Clean the holes by blowing ionized nitrogen and ensure particle counts less than 10
21. Change gloves
22. Remove the 4 finger tight studs and remove the loose blank flange and the right angle valve by rotating the assembly support table 90 degrees away from the cavity beam axis. Ensure that the aluminum gasket does not fall during removal of the flange. Argon purge will automatically start once the pressure inside the cavity #8 drops below 50 mbar.
23. Remove the 2 finger tight studs and move the loose plate from bellows rotatable flange downwards from the BPM holding it with your hand from the bottom edge. Argon purge will automatically start once the pressure inside the BPM drops below 50 mbar. [There is no space for a tool in the DESY clean room when all 8 cavities are assembled. That is why DESY does not use a fixture in this step. FNAL should design a fixture once the BPM/quad type is identified]
24. Install a new gasket to the Rotatable flange on the BPM bellow (ensure diamond seal is visually inspected)

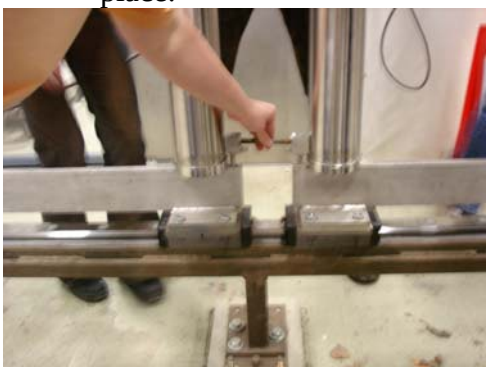
25. Slide the BPM and cavity #8 together. While pushing the BPM and cavity #8 together to keep the gasket under compression, install the studs and nuts to make the connection.



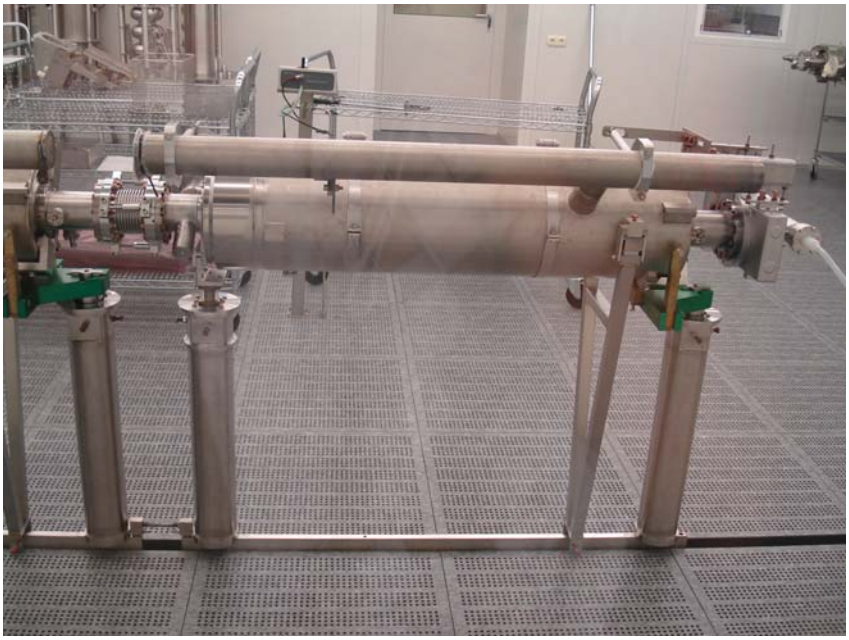
26. Torque the studs and nuts to 30 Newton-meter



27. Once the cavity#8, and BPM assembly are assembled, put the link fixture in place.



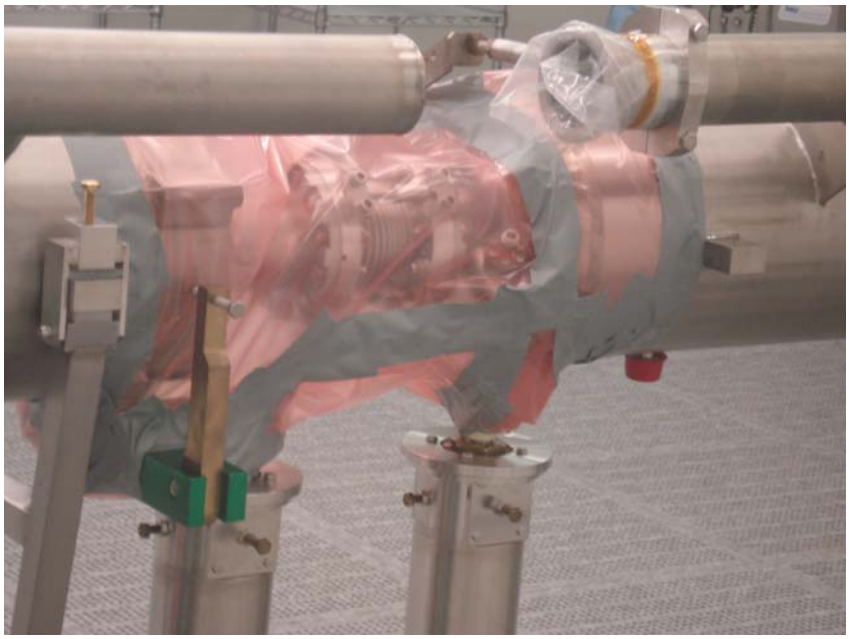
Miscellaneous Pictures:



Cavity#1 with gate valve connected to Cavity#2 with bellows

Cavity String assembled at clean room

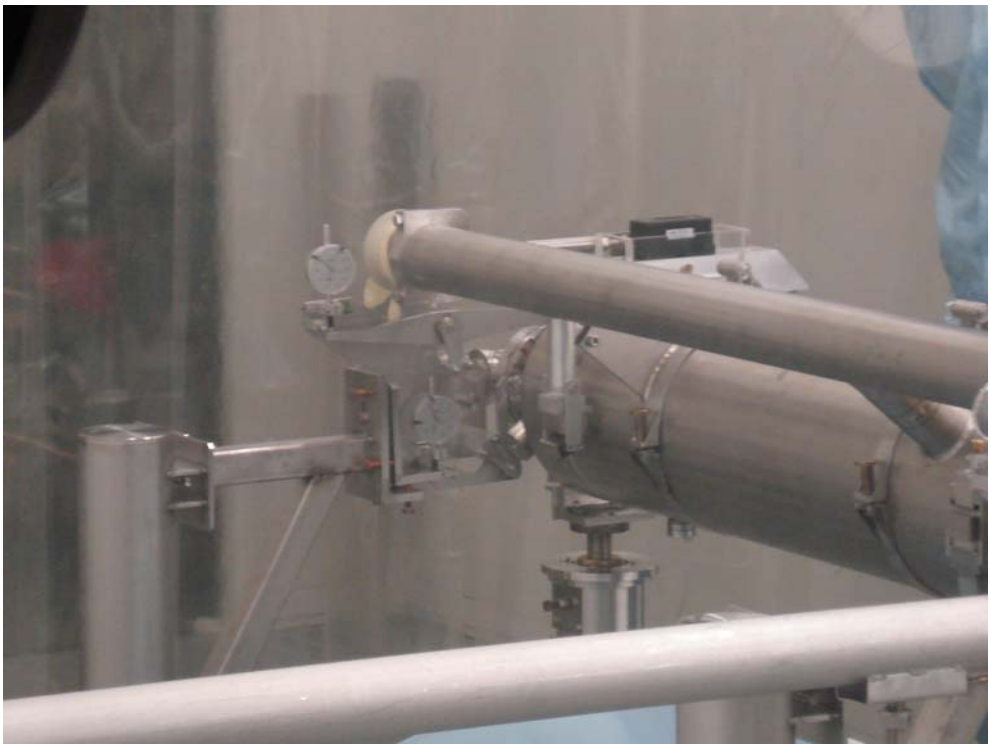
Cavity String with BPM/QUAD assembly connected



Bagged bellows connection for final helium leak checking

Cavity String with bagged bellows connection for final leak checking

Cavity beam axis X-Y alignment fixture in the clean room



Cavity short end beam pipe side X-Y alignment with alignment fixture

Cavity being aligned in Y direction for beam axis

Cavity Rotational Alignment precise level tool (with a bridge fixture)

Cavity being rotationally aligned